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THE EFFECT OF ARTIFICIAL SELECTION ON BRISTLE NUMBER IN DROSOPHILA AMPELOPHILA AND ITS INTERPRETATION

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About two years ago I began an experiment to test the effect of artificial selection in a bisexual form. Drosophila ampelophila was chosen after a careful search through the list of material which could be bred in the laboratory. There were two principal reasons for using this material. First, it is easily bred, and second, because of the four sets of linked genes described by Morgan and others, it is possible to better interpret how the results of selection have been accomplished. I wish to emphasize that the interpretation of the results is the important part of the problem. Practically every one admits that selection may be, in certain cases, effective.

The present work is not a repetition of McDowell's, although the character, bristle number, has been used. He used the bristles on the thorax, while I have used the bristles on the scutellum. Some of our final conclusions may agree, yet, the work is very different and I believe my own conclusions have been carried to a more definite termination. McDowell did not attempt to link up the factors which he believed the cause of extra bristle number with any other genes.

The experiment was started by mating a female with one extra bristle on the scutellum to a normal male (four bristles is the normal number). Both flies were taken from a mass culture which had been kept in the laboratory for about three months. Counts in this mass culture before the experiment began gave 612 normal flies and the one female with one extra bristle. The result of this cross (female five by normal male) was 226 normal flies and two females with one extra bristle. These two F_1 females with one extra bristle were mated to F_1 normal brothers. These two pairs gave F_2 offspring as follows: 935 normal, 39 with one extra bristle, and four with two extra bristles, a ratio of extras to normals of 1: 21.7. From these F_2 offspring, the flies with extra bristles were mated. This method of selecting the high grade parent has been continued for 38 generations. A rise in the per cent of extra bristled flies and also in the mean bristle number has been produced until in the last generations of selection no normal flies were found and the mean number of bristles in the twenty-ninth generation was 9.084. From the twenty-ninth to the thirty-eighth generation the mean remained practically the same. The highest bristle number found in any one individual fly was 15.

I cannot give details, but I think these figures are sufficient to show that selection has been effective. How then has it been effective? Have the results been produced by selecting merely somatic variations? Have they been produced by selecting the variations of a single gene, or have they been produced by getting rid of or by piling factors? The possibility that selection can act upon somatic variations, I believe, can now be dismissed without much consideration. Practically every one admits that variations must be germinal in order to be inherited. As to the second and third possibilities, my evidence is in favor of the third.

In the selection line the bristle number in the females is slightly higher than in the males. This indicated that there might be a sex-linked factor present, which when homozygous produced a different effect than when heterozygous. An experiment was devised to eliminate the X-chromosome but retain the others. This was done as follows: A male from the high selection line was mated to a bar female (bar is a sex-linked dominant). The F_1 males will get their X-chromosome from the bar female and hence will be bar. Of the other three pairs of chromosomes, one of each pair will come from the high selection line and the other from the bar line. Some of these F_1 males have extra bristles. These were mated to bar females from stock. All flies from this cross will get their X-chromosomes from the bar line. Some of them may get one member of each of the second, third, and fourth pairs from the high selection line. Since extra bristle number is partially dominant to the normal, such flies might have extra bristles if there are any genes for extra bristles in the second, third, or fourth chromosomes. Some of the flies from this cross did have extra bristles. They were mated and the line has been inbred to see whether the bristle number could be increased until it reached the mean in the high selection line. If so, then the X-chromosome could carry no gene for extra bristles. If the mean could not be raised, then it would indicate that the X-chromosome carried such a gene. Five generations of inbreeding has failed to raise the mean above 5.2.

Further, by crossing the high selection line to eosin, miniature and to eosin ruby forked (sex-linked characters), and mating the F_1 females back to the recessives, it comes out clearly that a gene influencing bristle number is located in the X-chromosome, somewhere near eosin. Of the cross-overs between eosin and miniature and between eosin ruby and forked, miniature and forked flies have a higher bristle number than the eosin, and eosin ruby.

The high selection line was also mated to black, pink, bent stock. The gene for black is in the second, that for pink in the third, and that for bent in the fourth chromosome. The F_1 flies were mated inter se and the F_1 males were mated back to black, pink, bent females. The normal, the black, and the bent flies from these crosses had a much higher bristle number than the pink flies. This fact indicated that there probably was a factor for bristle number in the third chromosome. To test this possibility the high selection line was mated to sepia spineless kidney sooty rough stock. The genes for these characters are located in the third chromosome. The F_1 females were mated to sepia spineless kidney sooty rough males. If crossing-over had occurred, this cross should have enabled me to link up the gene for extra bristles (if one is present) with one of the other genes. Unfortunately, only a low percentage of crossing-over occurs and hence the cross yielded no results.

Another method of analysis was used. A female from the high selection line was crossed to a sepia spineless kidney sooty rough male. The F_1 male from this cross was mated to a sepia spineless kidney sooty rough female. The offspring are normal females and males, and sepia spineless kidney sooty rough females and males. Some of the normal females and males and some of the sepia spineless kidney sooty rough females had extra bristles. None of the sepia spineless kidney sooty rough males had extra bristles. When the chromosomes of these flies are analyzed, it is found that the normal females may get one member of each of the second, third, and fourth chromosome pairs from the selection line and must get one of the X-chromosomes from this line. The normal males may get one chromosome of each of the second, third, and fourth chromosome pairs from the selection line, but they get their X-chromosome from the sepia, spineless, kidney, sooty, rough line. The sepia spineless kidney sooty rough females get both their third chromosomes from the sepia, spineless, kidney sooty rough line and may get one member of each of the second and fourth pairs from the selection line. They get one X-chromosome from the selection line and one from the other. The sepia spineless kidney sooty rough males, however, get their X-chromosome and both third chromosomes from the sepia spineless kidney sooty rough line and may get one chromosome of the second and fourth pairs from the selection line. Since these sepia spineless kidney sooty rough males have no extra bristles, it would seem that the X- and the third chromosomes carry the factors for extra bristle number.

A back selection line started from the eleventh generation and carried for twenty-five generations, changed slightly in the first few generations of selection and then remained practically unchanged. A mass culture started a year ago has not returned to the normal.

My conclusion then is that there are, at least, two factors for extra bristle number and that one of these is located in the first and one in the third chromosome. I am inclined to think there are more than two. It seems probable that one of these factors was present at the beginning of selection and that the others occurred as mutations during the course of the experiment.

The complete data and analysis will be given in the final paper.

THE REACTIONS OF THE MELANOPHORES OF AMIURUS TO LIGHT AND TO ADRENALIN

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Communicated by G. H. Parker, January 8, 1918

The following is a brief summary of results obtained in experiments to test the reactions of the melanophores in the skin of Amiurus to light and to adrenalin. The fishes tested were kept under as normal conditions as possible and no fish was used until it had become accustomed to its laboratory surroundings and to handling.

The melanophores of Amiurus contract under the influence of light of ordinary intensity and expand in the dark. Fish kept in white porcelain aquaria contract the melanophores to a much greater extent than do animals kept in black lined aquaria under similar conditions of overhead illumination. When the eyes are removed from normal healthy animals the latter remain dark under all light conditions. There are considerable differences in individuals with respect to the power of contraction of the melanophores. Some fishes become extremely light owing to complete contraction of the pigment cells; others, under similar conditions, never become so light. This cannot be explained entirely by the relative numbers of melanophores per unit area of body surface, as was shown by several counts. It may be due, possibly, to differences in nervous excitability.

If some 'sensitive' individuals are raised to a high pitch of nervous irritability, the melanophores are contracted to the maximum extent, and remain in this condition for a protracted period, even when the fishes are placed in the dark. One such fish was kept in the dark for three weeks and no expansion was observed in the melanophores. These cells appeared to be in a condition comparable to tetanus.

When such an 'excited' animal, with melanophores contracted, is etherized, the pigment cells expand and the fish becomes dark. On coming out of the ether, the melanophores contract slightly, but if the fish is now placed in the dark, the pigment cells gradually assume the expanded condition. If, however, the eyes are removed whilst the fish is under ether, there is no return to the contracted condition when the animal is subsequently kept in the light. The fact that there was no return to the contracted condition